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Moczygemba

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(54) **SYSTEM FOR THERMOELECTRIC ENERGY GENERATION**

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H01L 35/32 (2006.01)
H01L 35/34 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 35/32*** (2013.01); ***H01L 35/34*** (2013.01)

(58) **Field of Classification Search**
CPC H01L 35/30; H01L 35/32; H01L 35/34
USPC 136/201, 203, 205, 206, 211, 212, 230
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,304,207	A *	2/1967	Kolb	H01L 35/08	136/211
4,149,025	A *	4/1979	Niculescu	H01L 35/00	136/203
5,002,336	A *	3/1991	Feher	A47C 7/744	297/180.13
5,430,322	A *	7/1995	Koyanagi	B64G 1/421	136/203
6,509,520	B1	1/2003	Kyle et al.	136/201	

(Continued)

FOREIGN PATENT DOCUMENTS

FR	1 363 072 A	6/1964		
JP	2006086210 a *	3/2006		
WO	WO 03/071198 A1	8/2003		F25B 21/02

OTHER PUBLICATIONS

Jp2006086210a, Mar. 30, 2006, Hino et al., English equivalent of the abstract.*

(Continued)

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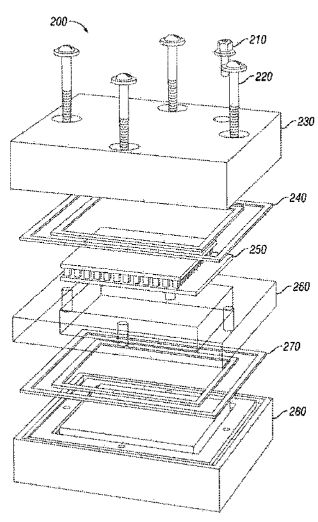
(57) **ABSTRACT**

A system includes a first plate and a second plate. The first plate is arranged to be thermally coupled to a first surface and the second plate is arranged to be thermally coupled to an environment. The environment has a temperature that is different than the first surface. The system also includes a thermoelectric device that includes a plurality of thermoelectric elements. The thermoelectric device includes a third plate coupled to the plurality of thermoelectric elements and thermally coupled to the first plate. The thermoelectric device also includes a fourth plate coupled to the plurality of thermoelectric elements and thermally coupled to the second plate. The system also includes a dielectric fluid arranged between the first plate and the second plate. The thermoelectric elements are submersed in the dielectric fluid.

18 Claims, 8 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0148235	A1*	10/2002	Bell	F02G 1/043 62/3.3
2004/0094194	A1*	5/2004	Aldoretta	H01L 31/042 136/251
2010/0119770	A1*	5/2010	Hiroyama	H01L 35/32 428/131

OTHER PUBLICATIONS

PCT Notification of Transmittal of the International Search Report and the Written Opinion of the International Searching Authority, or the Declaration and Written Opinion of the International Searching Authority for International Application No. PCT/US2013/063352, 9 pages, Dec. 20, 2013.

* cited by examiner

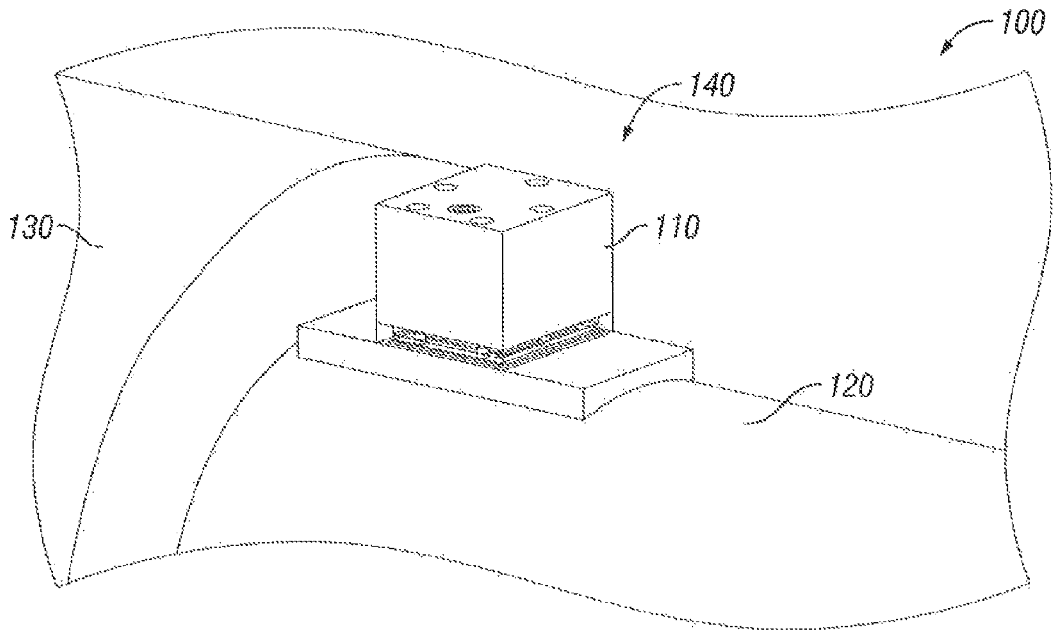


FIG. 1A

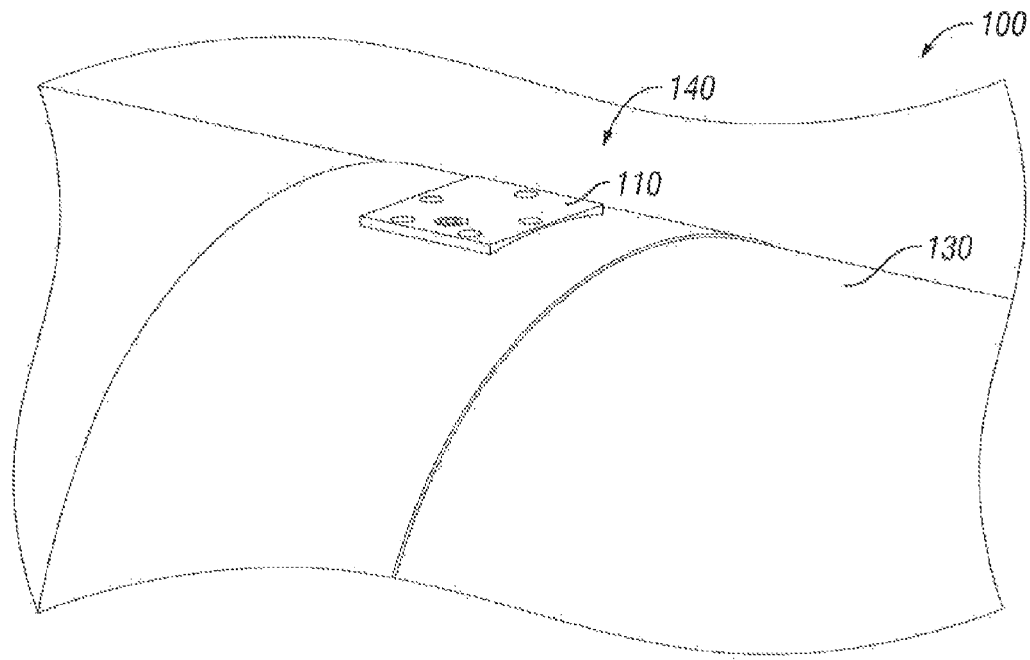


FIG. 1B

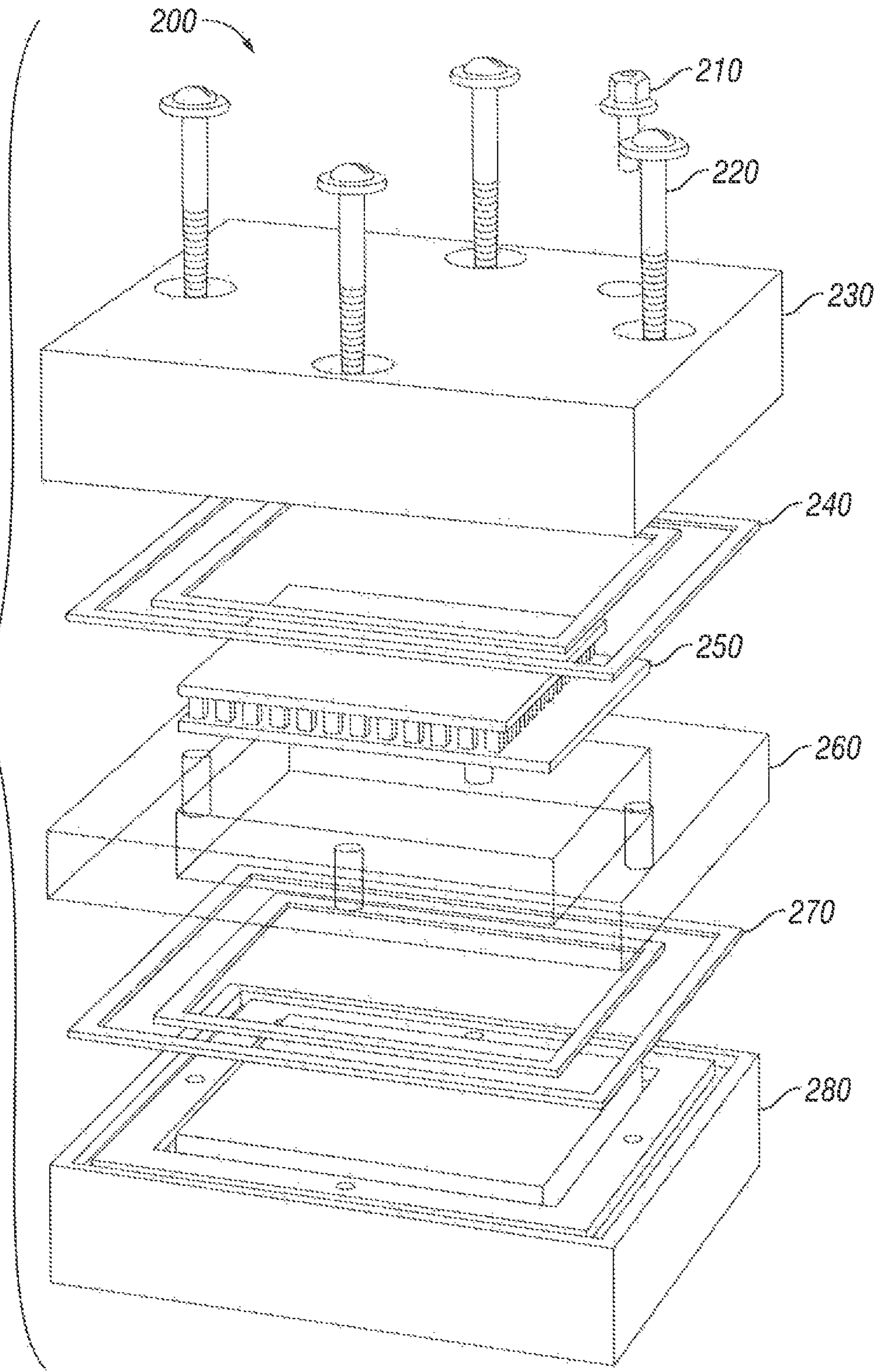


FIG. 2

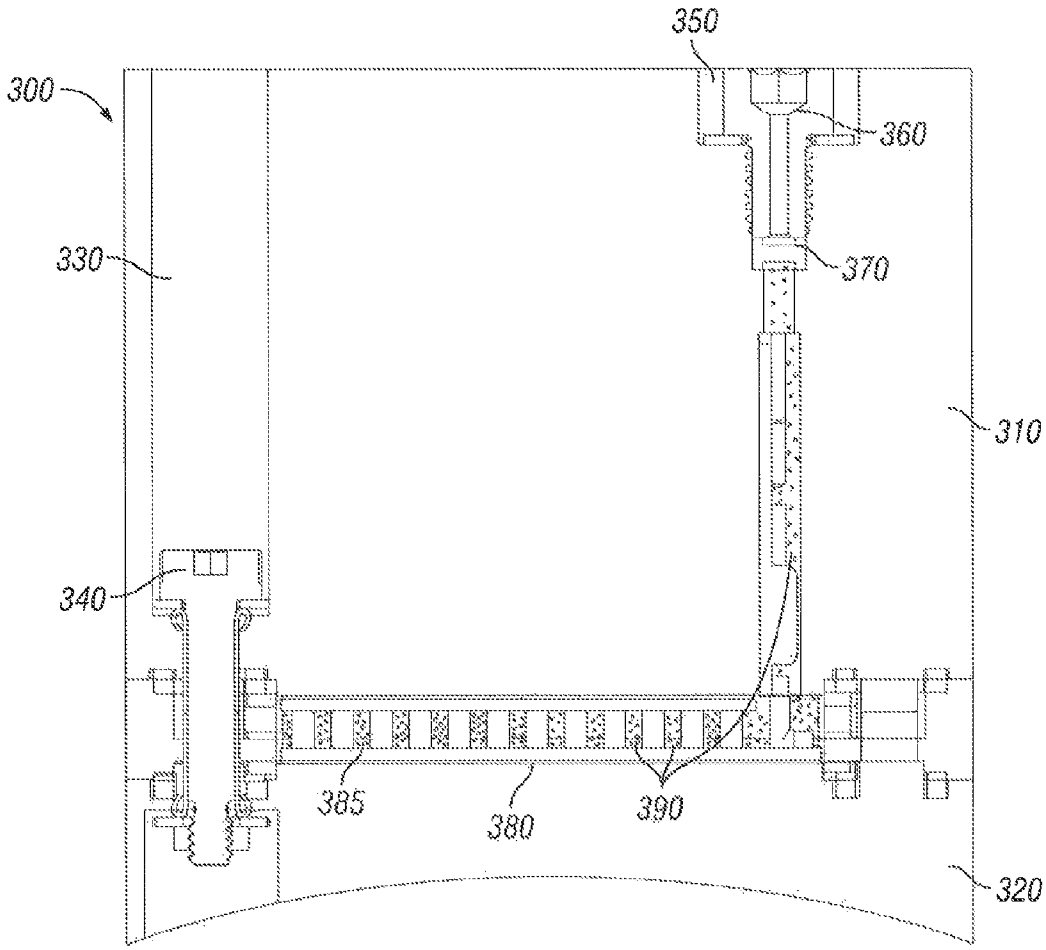


FIG. 3

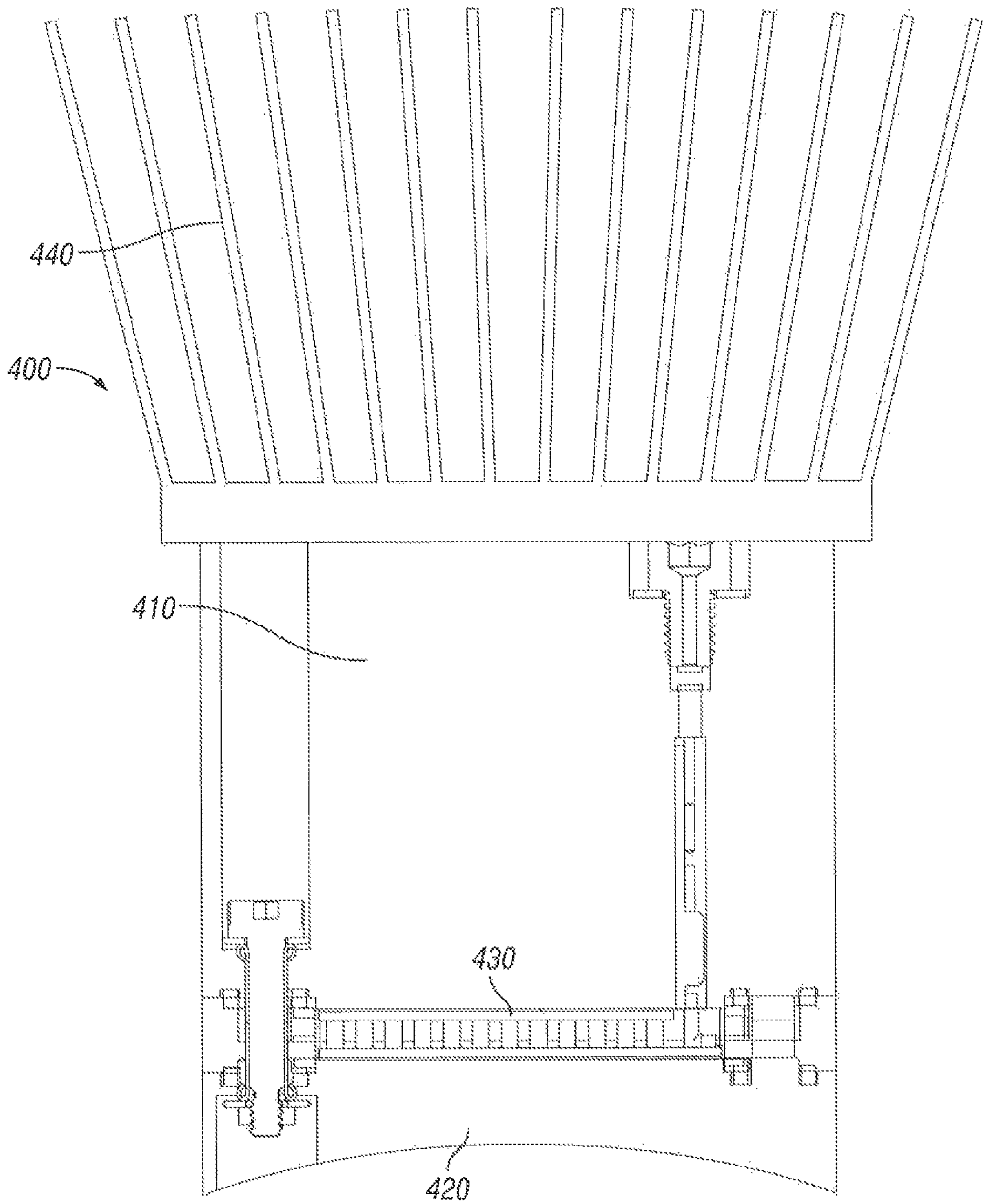


FIG. 4

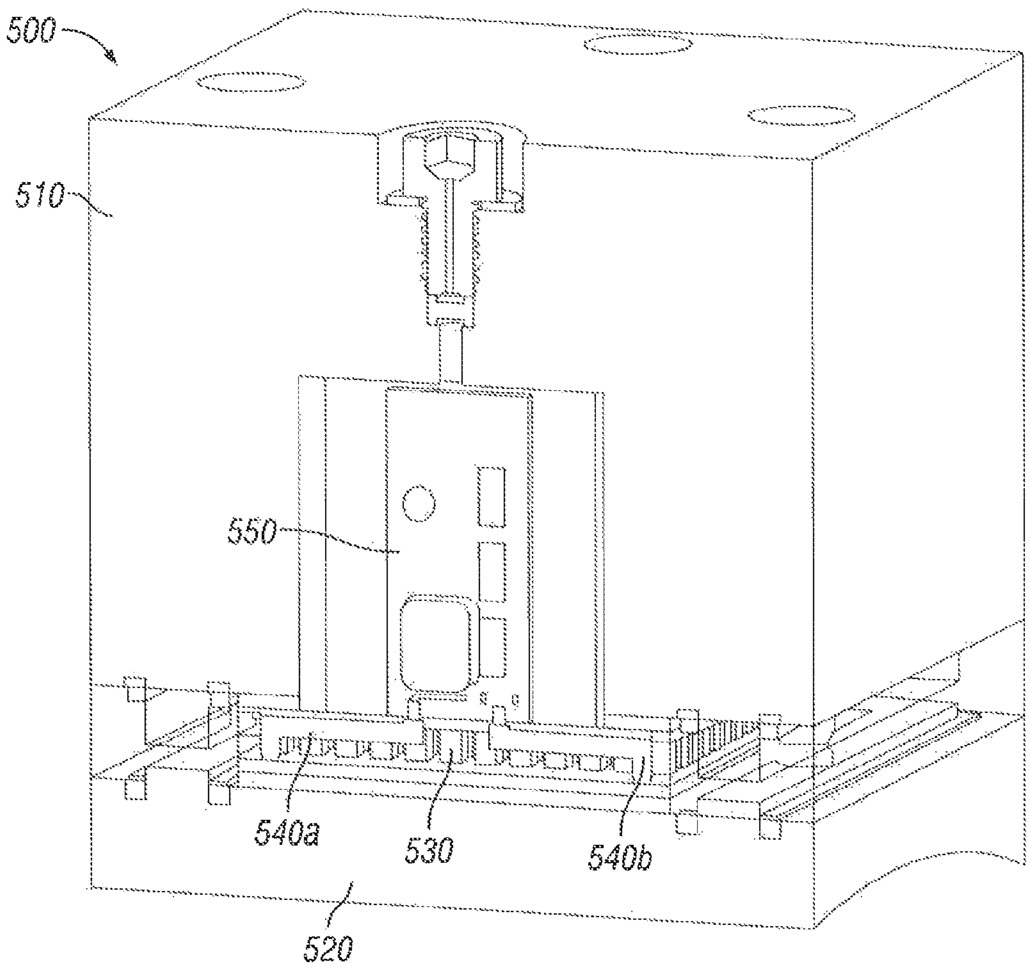


FIG. 5

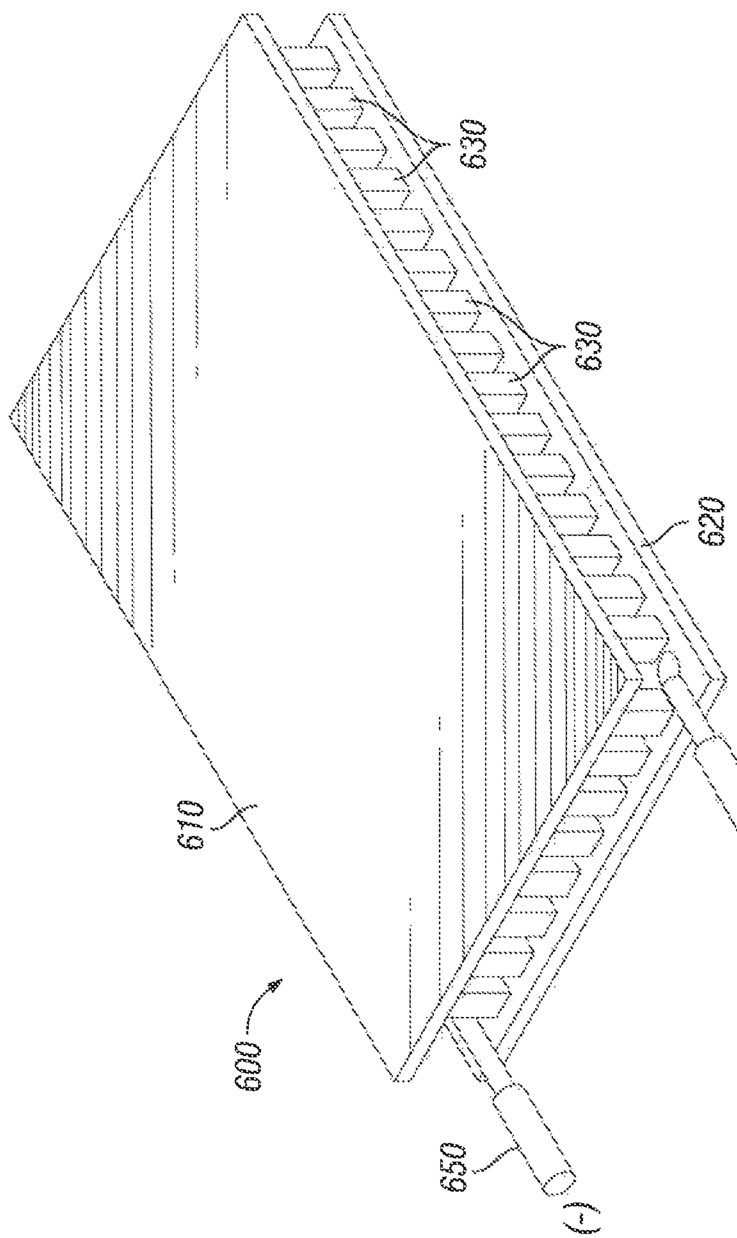


FIG. 6

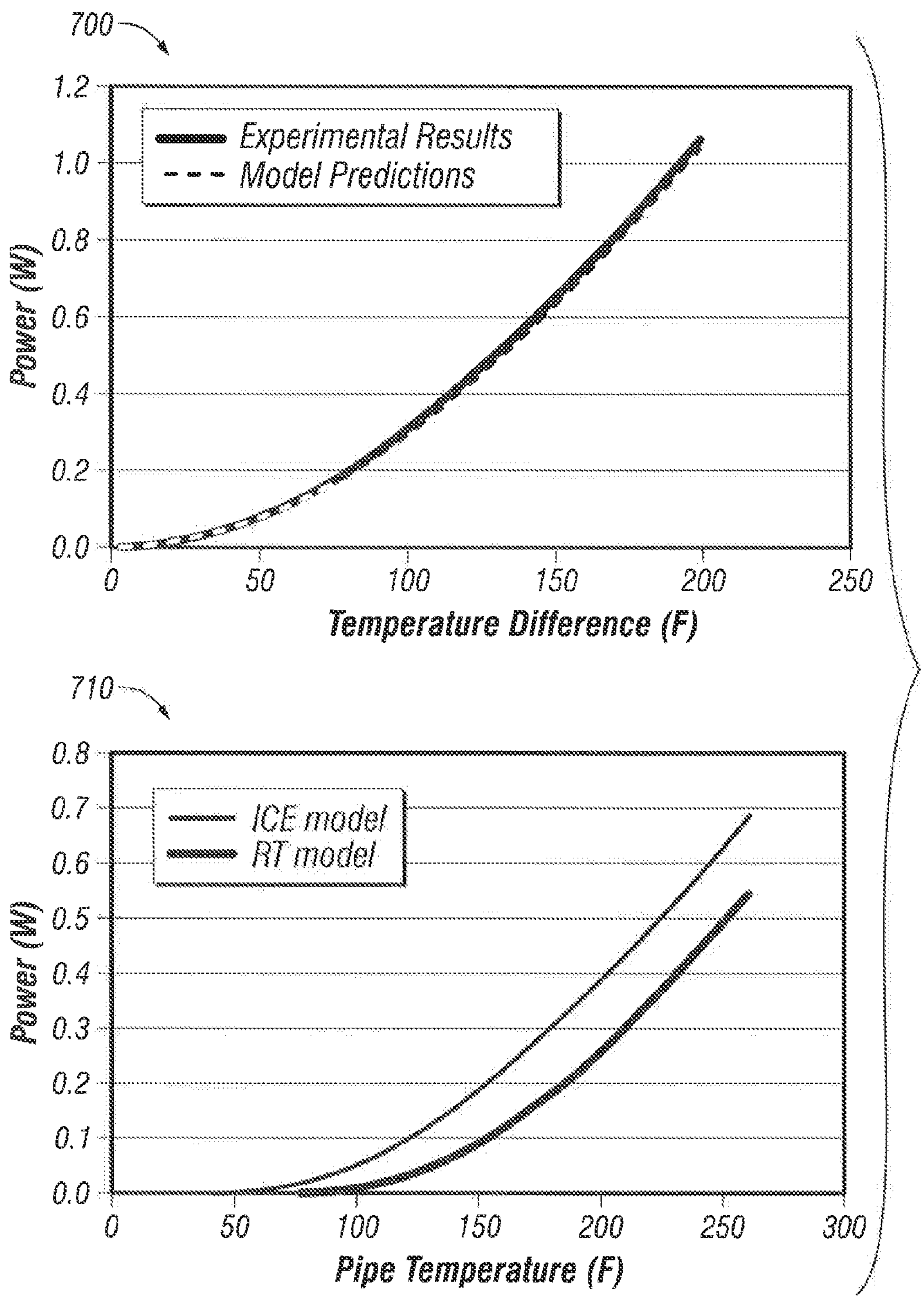

700
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Power (W)
Experimental Results
Model Predictions
0
50
100
150
200
250
Temperature Difference (F)
710
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Power (W)
ICE model
RT model
0
50
100
150
200
250
300
Pipe Temperature (F)

FIG. 7A

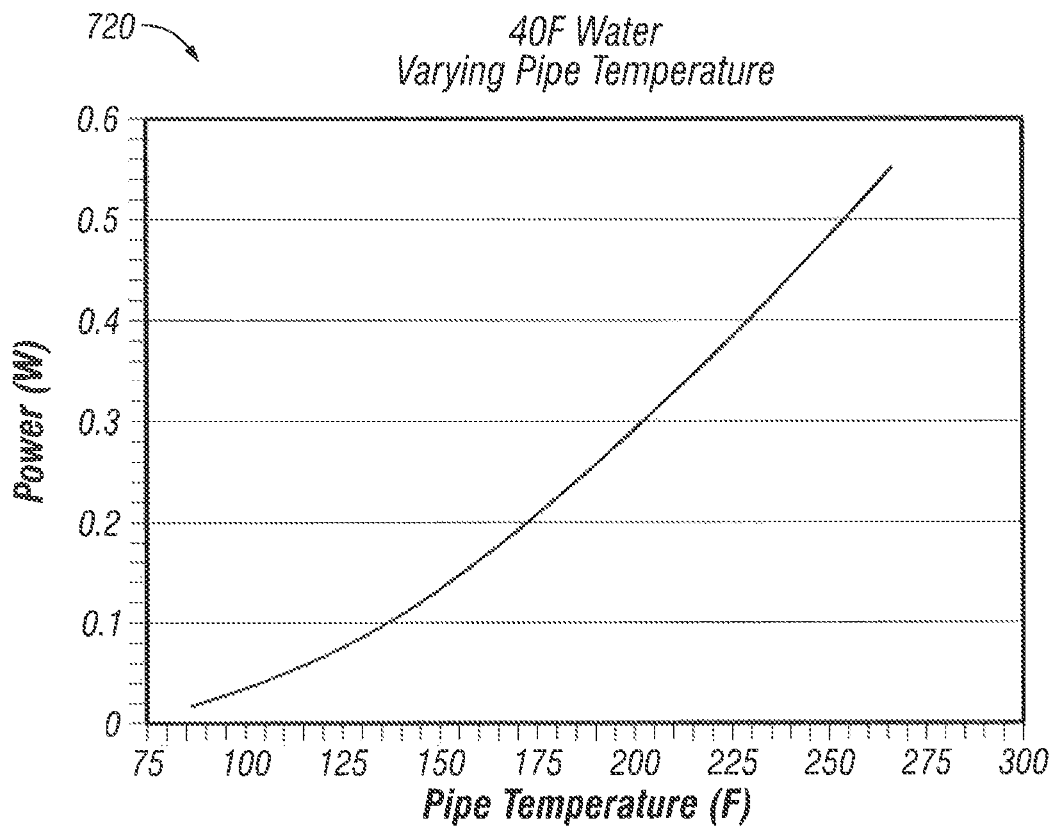

720
40F Water
Varying Pipe Temperature
Power (W)
0.6
0.5
0.4
0.3
0.2
0.1
0
75
100
125
150
175
200
225
250
275
300
Pipe Temperature (F)

FIG. 7B

SYSTEM FOR THERMOELECTRIC ENERGY GENERATION

RELATED APPLICATION

This application claims benefit under 35 U.S.C. §119(e) of U.S. Provisional Application Ser. No. 61/709,895, titled "A System For Thermoelectric Energy Generation," filed Oct. 4, 2012, by Joshua E. Moczygemba and U.S. Provisional Application Ser. No. 61/745,413, titled "A System For Thermoelectric Energy Generation," filed Dec. 21, 2012, by Joshua E. Moczygemba.

TECHNICAL FIELD

This disclosure relates to generally to energy generation and more particularly to a system for thermoelectric energy generation.

BACKGROUND

The basic theory and operation of thermoelectric devices has been developed for many years. Presently available thermoelectric devices used for cooling typically include an array of thermocouples that operate in accordance with the Peltier effect. Thermoelectric devices may also be used for heating, power generation, and temperature sensing.

A thermoelectric device produces electrical power from heat flow across a temperature gradient. As the heat flows from hot to cold, free charge carriers in the thermoelectric material are also driven to the cold end. The resulting voltage is proportional to the temperature difference via the Seebeck coefficient.

SUMMARY

In one embodiment, a system includes a first plate and a second plate. The first plate is arranged to be thermally coupled to a first surface and the second plate is arranged to be thermally coupled to an environment. The environment has a temperature that is different than the first surface. The system also includes a thermoelectric device that includes a plurality of thermoelectric elements. The thermoelectric device includes a third plate coupled to the plurality of thermoelectric elements and thermally coupled to the first plate. The thermoelectric device also includes a fourth plate coupled to the plurality of thermoelectric elements and thermally coupled to the second plate. The system also includes a dielectric fluid arranged between the first plate and the second plate. The thermoelectric elements are submersed in the dielectric fluid.

In some embodiments, a gasket may be situated within a groove of the first plate. The system may include a wall situated between the first plate and the second plate. The wall may be situated around the thermoelectric device. The wall may include thermally insulative material.

In one embodiment, a method includes thermally coupling a first plate to a first surface and thermally coupling a second plate to an environment. The environment has a temperature that is different than the first surface. The method further includes generating electricity using a thermoelectric device based on a temperature gradient between the first plate and the second plate. The thermoelectric device includes a plurality of thermoelectric elements submersed in a dielectric fluid. The thermoelectric device also includes a third plate coupled to the plurality of thermoelectric elements and thermally coupled to the first plate as well as a fourth plate coupled to the plurality of thermoelectric elements and thermally coupled to the second plate.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference is now made to the following description taken in conjunction with the accompanying drawings, wherein like reference numbers represent like parts.

FIGS. **1**A and **1**B illustrate one embodiment of a system that is configured to generate electric energy.

FIG. **2** is an exploded view of one embodiment of a thermoelectric generator.

FIG. **3** is a side view of one embodiment of a thermoelectric generator including a diaphragm.

FIG. **4** is a side view of one embodiment of a thermoelectric generator that incorporates a fin.

FIG. **5** is a side view of one embodiment of a thermoelectric generator that incorporates an electronic device.

FIG. **6** illustrates one embodiment of a thermoelectric device.

FIGS. **7**A and **7**B are a set of charts depicting examples of performance characteristics of embodiments of thermoelectric generators.

DETAILED DESCRIPTION

FIGS. **1**A and **1**B illustrate one embodiment of system **100** that is configured to generate electrical energy. In some embodiments, pipe **120** is in a high pressure (e.g., 100-10,000 psi) environment **140** (e.g., deep sea water, such as 10,000 feet below sea level at approximately 40 degrees Fahrenheit) and contains a hot (e.g., between 100 and 300 degrees Fahrenheit) medium (e.g., liquid or gas). As such, there is a temperature gradient between pipe **120** and environment **140** (e.g., a gradient between 50 and 200 degrees Fahrenheit). Thermoelectric generator **110** is situated such that one side of generator **110** is thermally coupled to pipe **120** (e.g., by being secured directly to pipe **120** or with suitable thermal interface materials such as graphite pads, grafoil, or other thermal pads situated between pipe **120** and generator **110**) while another side of generator **110** is exposed to environment **140**. Thermoelectric generator **110** is situated inside insulation **130** that covers pipe **120** such that a side of generator **110** is still exposed to environment **140** (as depicted in FIG. **1**B). Thermoelectric generator **110** is configured to generate electricity based on the temperature difference between pipe **120** and environment **140** using the Seebeck effect. In some embodiments, generator **110** may be a reliable source of electrical energy suitable to power electronics such as sensors due to the near constant temperature difference between pipe **120** and environment **140**. In some embodiments, pipe **120** may contain a cold medium and environmental **140** may be hot; thermoelectric generator **110** may provide electrical energy in this situation due to the temperature difference between pipe **120** and environment **140**.

In some embodiments, high pressure environment **140** may include environments such as deep sea water. Another example of environment **140** is the interior of a pressure vessel. Yet another example of environment **140** is the interior of a pipeline. Thus, while the present disclosure discusses deep sea water as an example environment, the disclosure is applicable in other environments, such as those that have higher than normal pressure and those that lead to temperature gradients between the environment and devices in the environment.

In some embodiments, system **100** may be a continuous power source designed to harvest thermal energy (e.g., from subsea pipelines). The large temperature gradients between the pipelines and water may facilitate sustained, long term thermal energy harvesting. An example utility of this is avoiding battery replacement which may not be an economical option in such an environment. Example advantages of embodiments of system **100** are that system **100** may provide perpetual or continual, no maintenance power for subsea or deep sea applications. As another example, system **100** can be used to implement a sustainable, low-cost solution to monitoring ocean floor pipelines. Typically, ocean floor pipelines are costly to monitor and repair, especially after they have been substantially damaged. Using system **100**, problems may be detected beforehand and costly repairs can be avoided. For example, electrical energy produced by system **100** can then be used to power low-power electronics that can be used to monitor a pipeline in a convenient package which can be attached to the pipeline during a field jointing process.

FIG. **2** is an exploded view of one embodiment of thermoelectric generator **200** that may be used to implement thermoelectric generator **110** of FIGS. **1**A and **1**B. Cold side plate **230** is fastened to hot side plate **280** using fasteners **220** (e.g., nails, screws, and/or rivets). Thermoelectric device **250** is situated between plates **230** and **280** such that one side of thermoelectric device **250** is thermally coupled to plate **230** while another side of thermoelectric device **250** is thermally coupled to plate **280**. Immediately surrounding thermoelectric device **250** is wall **260**. Plates **230** and **280** as well as wall **260** may have grooves that are configured to receive gaskets **240** and **270**. Plate **230** may also include an orifice that allows for fluid to be poured into generator **200** once it is assembled and that orifice may be sealed using plug **210**.

In some embodiments, plates **230** and **280** can be titanium, stainless steel, aluminium, 90Cu10Ni alloy, or any bare or coated metal. In some embodiments, plates **230** and **280** may provide long term protection against sea water. In some embodiments, exterior sided edge insulation (suck as insulation **130**) may be placed around the side edges of the housing (e.g., around plates **230** and **280**) to further insulate thermoelectric generator **200** from thermal shorting (e.g., due to sea water in applicable circumstances).

In some embodiments, gaskets **240** and **270** may be hydraulic gaskets. Materials such as viton, nitrile, hydrogenated nitrile, fluorsilicone, epdm, silicone may be employed to form gaskets **240** and **270**. Gaskets **240** and **270** may prevent mixing of hydraulic fluid and sea water.

In some embodiments, wall **260** may be a low conductivity wall. For example, thermally insulative materials (e.g., polysulfone, Teflon, polycarbonate, nitrile, acrylic) may be used to form wall **260**. This may reduce, minimize, or prevent thermal shorting from the hot side to the cold side of thermoelectric generator **200**. This can be used to help force heat through thermoelectric device **250**.

In some embodiments, thermoelectric generator **200** may produce electrical energy when a temperature difference exists between plates **230** and **280**. Gaskets **240** and **270** may allow generator **200** to operate in aquatic environments such as deep sea water. Wall **260** may allow generator **200** to operate in the presence of high pressure such as those encountered in deep sea water. An example advantage is that gaskets **240** and **270** as well as low pressure differences between the inside of thermoelectric generator **200** and its environment may allow for using materials with low thermal conductivity to reduce or minimize reduction in performance due to thermal shorting. Another example advantage is that thermal shorting effects through housing of thermoelectric generator **200** may be reduced. For example, materials used for plates **230** and **280** as well as wall **260** can be chosen to avoid thermal shorting. As another example, thermal shorting can be avoided by allowing for plates **230** and **280** to have different shapes and thicknesses than what is typically used in high pressure environments.

In some embodiments, a configuration of thermoelectric generator **200** may eliminate wall **260** as well as gaskets **240** and **270** and replace them with a single hydraulic gasket. The size, shape and material of this single hydraulic gasket could be tailored to minimize conduction between plates **230** and **280**. One or more thin layers of dielectric hydraulic fluid (e.g., mineral oil, silicone oil, or vegetable oil) may serve as thermal interfaces between thermoelectric device **250** and plates **230** and **280**. In some embodiments, graphite pads, grafoil, or other thermal pads may serve as thermal interfaces between thermoelectric device **250** and plates **230** and **280**. Dielectric hydraulic fluids may be used in combination with thermal pads as thermal interfaces between thermoelectric device **250** and plates **230** and **280**.

FIG. **3** is a side view of one embodiment of thermoelectric generator **300**. Thermoelectric generator ("TEG") **300** may be used to implement thermoelectric generator **200** of FIG. **2** and thermoelectric generator **110** of FIGS. **1**A and **1**B. Cold side plate **310** is fastened to hot side plate **320** using fastener **340** through channel **330**. Thermoelectric device **380** is situated between plates **310** and **320** such that one side of thermoelectric device **380** is thermally coupled to plate **310** and another side of thermoelectric device **380** is thermally coupled to plate **320**. Orifice **350** provides a manner in which to introduce substances into thermoelectric generator **300** such as fluid **390**. Orifice **350** is sealed using plug **360**. Diaphragm **370** may interface with plug **360**. Some or all of the spaces between and/or around thermoelectric elements of thermoelectric device **380** may include baffles **385** (e.g., open cell hexagonal strips). In some embodiments, thermoelectric generator **300** can handle very large isostatic pressures. Testing has shown that 10,000 psi under isostatic conditions poses no significant change to performance of thermoelectric device **380**.

In some embodiments, diaphragm **370** can allow for pressure equalization in the event air is trapped in the interior portion of the block. One mechanism by which this could occur with thermoelectric modules is the collapsing or air pockets entrained in solder joints as isostatic pressure increases. In such a case, diaphragm **370** would be sized so as to compensate for the change in internal volume of housing in TEG **300**. Diaphragm **370** would then displace, rather than housing of TEG **300** needing to support, the pressure differential.

In some embodiments, fluid **390** may be a low thermal conductivity, dielectric, incompressible fluid. In some embodiments, a fluid counteracts the external pressure of the seawater at large depths (reducing the need for thick walls for housing of TEG **300**) and evenly distributes the pressure to every surface of the TEG module. For example, a hollow egg crushes quickly at low depth, but the same egg completely filled with an incompressible fluid could be submerged to large depths (e.g., the bottom of the Marianas Trench) without rupture. Also, since fluid **390** has a low thermal conductivity, transfer of heat from hot pipe to cold plate through the fluid is minimized. In some embodiments, the need for thick housing walls and strong materials is also reduced, significantly reducing thermal bypass through these walls (around TEG **300**) from hot to cold side. In some embodiments, such a design significantly increases power output of TEG **300** (because the excess heat does not saturate the cold plate). Fluid **390** may be a hydraulic fluid (e.g., k=0.13 W/m-K), such as mineral oil, silicone oil, or vegetable oil to minimize thermal conductions losses through fluid **390** from hot to cold reservoirs. In some embodiments, liquid **390** may include a low thermal conductivity, non-compressible filer (e.g., a powder that is incompressible and not electrically conductive such as aluminum oxide, silicate, or ceramic type powders) or other suitable alternatives. The filler can be used to prevent convection currents. Also, a thin layer of fluid **390** can serve to aid or replace thermal interface material between thermoelectric device **380** and plates **310** and **320** thereby reducing the thermal interface contact resistance.

In some embodiments, thermoelectric generator **300** includes aspects that may facilitate generation of electric energy in high pressure environments such as deep sea water based on temperature differences between plates **310** and **320**. For example, dielectric fluid **390** may be used to alleviate differential pressures. As another example, baffles **385** and/or filler material may be used to suppress convection currents.

FIG. **4** is a side view of one embodiment of thermoelectric generator ("TEG") **400** that incorporates fin **440**. Thermoelectric generator **400** may be used to implement thermoelectric generator **200** of FIG. **2** and thermoelectric generator **110** of FIGS. **1**A and **1**B. Cold side plate **410** and hot side plate **420** are each thermally coupled to different sides of thermoelectric device **430**. Fin **440** is situated on cold side plate **410** and may assist in heat transfer to the environment in which thermoelectric generator **400** is situated (e.g., deep sea water).

In some embodiments, fin **440** may be any fixture capable of increasing the surface area over which TEG **400** may exchange thermal energy with its environment. For example, fin **440** may be a zipped or stacked fin heat exchanger comprising a plurality of closely-spaced fins separated from one another by a series of spaces. Each fin may include one or more flanges or other features operable to interlock the plurality of fins together into a single, unitary array. For example, flanges may be a series of frusto-conically-shaped perforations in fin **440** that are nested inside one another to link each of the individual fins together. Fin **440** may include a plurality of zipped fin structures, with each having a flat bottom coupled to a plurality of parallel fins. Fin **440** may be implemented using extrusion or skiving processes. Fin **440** may be a folded fin structure comprising a single sheet of material that has been consecutively folded over onto itself to create a single array of closely spaced fins. Fin **440** may include a lateral (e.g., generally L-shaped) fold at one end that, when aggregated together, form a flat.

FIG. **5** is a side view of one embodiment of thermoelectric generator **500** that incorporates an electronic device. Cold side plate **510** and hot side plate **520** are each thermally coupled to different sides of thermoelectric devices **530**. Electrical energy is generated by thermoelectric device **530** as a result of temperature differences between plates **510** and **520** and can be directed to electronic component **550** via leads **540***a-b*. Electronic component **550** is situated within cold side plate **510**. Examples of electronic component **550** include circuit boards, power storage, sensors, and transmitters.

FIG. **6** illustrates one embodiment of thermoelectric device **600** that may be used to implement thermoelectric device **250** of FIG. **2**, thermoelectric device **380** of FIG. **3**, thermoelectric device **430** of FIG. **4**, and thermoelectric device **530** of FIG. **5**. Thermoelectric device **600** includes a plurality of thermoelectric elements **630** disposed between plates **610** and **620**. Electrical terminals **640** and **650** are provided to allow thermoelectric device **600** to be electrically coupled with to one or more devices that use, transform, or store electrical power.

In some embodiments, thermoelectric elements **630** fabricated from dissimilar semiconductor materials such as N-type thermoelectric elements and P-type thermoelectric elements. Thermoelectric elements **630** are typically configured in a generally alternating N-type element to P-type element arrangement and typically include an air gap disposed between adjacent N-type and P-type elements. In many thermoelectric devices, thermoelectric materials with dissimilar characteristics are connected electrically in series and thermally in parallel.

Examples of thermoelectric devices and methods of fabrication are shown in U.S. Pat. No. 5,064,476 titled Thermoelectric Cooler and Fabrication Methods; U.S. Pat. No. 5,171,372 titled Thermoelectric Cooler and Fabrication Method; and U.S. Pat. No. 5,576,512 titled Thermoelectric Apparatus for Use With Multiple Power Sources and Method of Operation.

N-type semiconductor materials generally have more electrons than would be found in the associated ideal crystal lattice structure. P-type semiconductor materials generally have fewer electrons than would be found in the associated ideal crystal lattice structure. The "missing electrons" are sometimes referred to as "holes." The extra electrons and extra holes are sometimes referred to as "carriers." The extra electrons in N-type semiconductor materials and the extra holes in P-type semiconductor materials are the agents or carriers that transport or move heat energy between plates **610** and **620** through thermoelectric elements **630** when subject to a DC voltage potential. These same agents or carriers may generate electrical power when an appropriate temperature difference is present between plates **610** and **620**. Terminals **640** and **650** may be coupled to one of plates **610** and **620** in a manner that withstands high temperature environments, such as resistance welding, tungsten inert gas (TIG) welding, and laser welding.

In some embodiments, thermoelectric elements **630** may include high temperature thermoelectric material. Examples of high temperature thermoelectric materials include lead telluride (PbTe), lead germanium telluride (PbxGe1-xTe), TAGS alloys (such as (GeTE)0.85(AgSbTe2)0.15), bismuth telluride (Bi2Te3) based alloys, and skutterudies.

In some embodiments, thermoelectric elements **630** may include a diffusion barrier that includes refractory metals (e.g., a metal with a melting point above 1,850° C.). Suitable refractory metals may include those that are metallurgically compatible with high temperature thermoelectric materials and metallurgically compatible with other components of thermoelectric device **600**. For example, a molybdenum diffusion barrier may be used. This may be advantageous in that molybdenum may be metallurgically compatible with various aspects of thermoelectric device **600**. For example, as further discussed below, thermoelectric device **600** may include an aluminum braze that is metallurgically compatible with a molybdenum diffusion barrier. Such a diffusion barrier may prevent or reduce the change or occurrence of Kirkendall voiding in thermoelectric device **600**. Other suitable examples of diffusion barrier materials that could have similar properties to molybdenum include tungsten and titanium.

In some embodiments, alternating thermoelectric elements **630** of N-type and P-type semiconductor materials may have their ends connected by electrical conductors.

Conductors may be metallization formed on thermoelectric elements **630** and/or on the interior surfaces of plates **610** and **620**. Conductors may include aluminum. Ceramic materials may be included in plates **610** and **620** which define in part the cold side and hot side, respectively, of thermoelectric device **600**. In some embodiments, the ceramic materials may provide electrical isolation from hot and cold side sources. Aluminum metallized ceramics may accommodate thermal stresses (i.e., due to high temperature exposure) of the ceramic/aluminum bond. Examples of suitable ceramic materials include anodized aluminum, aluminum oxide, aluminum nitride, and beryllium oxide.

In some embodiments, thermoelectric elements **630** may be coupled to plates **610** and **620** using a medium. The medium may include brazes and/or solders. For example, aluminum-based brazes and/or solders may be used, such as aluminum-silicon (Al—Si) braze family and/or zinc-aluminum (Zn—Al) solder. In some embodiments, using such brazes and/or solders may provide for high temperature operation and allow for flexible joints. Kirkendall voiding may be prevented or reduced.

FIGS. **7**A and **7**B are a set of charts depicting examples of performance characteristics (based on models and experiments) of embodiments of thermoelectric generators configured as described above with respect to FIGS. **1A-6**. Chart **700** depicts power output (both of a model and experimental results) of a thermoelectric generator, such as thermoelectric generator **110** of FIG. **1**A, as a result of the amount of temperature difference present (e.g., the difference in temperature between pipe **120** and environment **140** of FIG. **1**A). The following table provides examples of the values used in chart **700**:

Temperature Difference (F.)	Power (Watts)	Model (Watts)
200.192	1.067	1.050
200.176	1.066	1.050
158.731	0.707	0.691
157.284	0.696	0.679
128.209	0.474	0.465
94.964	0.268	0.262
73.661	0.164	0.160
54.983	0.093	0.090
45.232	0.063	0.061
44.779	0.062	0.060
32.362	0.033	0.032
32.011	0.032	0.031
25.349	0.020	0.019
25.103	0.020	0.019
21.568	0.015	0.014
21.353	0.014	0.014
17.838	0.010	0.010
13.450	0.006	0.006
10.690	0.004	0.003
7.576	0.002	0.002
5.546	0.001	0.001
3.719	0.001	0.000
2.878	0.000	0.000

Charts **710** and **720** indicate power outputs of a thermoelectric generator, such as thermoelectric generator **110** of FIG. **1**A, as compared to the temperature of a pipe (e.g., pipe **120** of FIG. **1**A) to which the thermoelectric generator is attached. Chart **710** is the result of experiments where ice water ("ICE"), at 4.44 degrees Celsius, is used and where room temperature ("RT") water, at 25 degrees Celsius, is used. The following tables provide examples of the values used in chart **710**:

Ice	
Pipe Temperature (F.)	Power (Watts)
42.8	0.0
49.6	0.001
67.1	0.009
80.6	0.021
98.6	0.047
103.6	0.057
108.5	0.067
120.2	0.095
131.0	0.125
152.6	0.196
162.5	0.233
176.5	0.288
196.3	0.371
210.7	0.435
225.5	0.505
260.2	0.681

Room Temperature	
Pipe Temperature (F.)	Power (Watts)
42.8	0.000
49.6	0.000
67.1	0.000
80.6	0.000
98.6	0.008
103.6	0.012
108.5	0.016
120.2	.095
131.0	0.049
152.6	0.097
162.5	0.125
176.5	0.170
196.3	0.244
210.7	0.304
225.5	0.372
260.2	0.543

Chart **720** is the result of experiments where water at 40 degrees Fahrenheit is used. The following table provides examples of the values used in chart **720**:

Pipe Temperature (F.)	Power (Watts)
266	0.551
230	0.403
194	0.272
158	0.157
122	0.071
86	0.018

Depending on the specific features implemented, particular embodiments may exhibit some, none, or all of the following technical advantages. By enabling deep sea operation, TEG energy harvesting may be a solution for deep water monitoring of oil pipe lines. A housing for a thermoelectric generator that can withstand significant amount of pressure yet also allow heat to be transferred through a thermoelectric device has been described. Other technical advantages will be readily apparent to one skilled in the art from the preceding figures and description as well as the proceeding claims and appendices. Particular embodiments may provide or include all the advantages disclosed, particular embodiments may provide none of the advantages disclosed.

Although several embodiments have been illustrated and described in detail, it will be recognized that modifications and substitutions are possible.

What is claimed is:

1. A system comprising:
a first plate, the first plate arranged to be thermally coupled to a first surface;
a second plate, the second plate arranged to be thermally coupled to an environment, the environment comprising a temperature that is different than the first surface;
a thermoelectric device, comprising:
a plurality of thermoelectric elements;
a third plate coupled to the plurality of thermoelectric elements and thermally coupled to the first plate;
a fourth plate coupled to the plurality of thermoelectric elements and thermally coupled to the second plate; and
dielectric fluid arranged between the first plate and the second plate, the thermoelectric elements submersed in the dielectric fluid, wherein the dielectric fluid comprises non-compressible filler.

2. The system of claim 1, further comprising a first gasket situated within a groove of the first plate and a second gasket situated within a groove of the second plate.

3. The system of claim 1, further comprising a wall situated between the first plate and the second plate, the wall situated around the thermoelectric device, the wall comprising thermally insulative material.

4. The system of claim 1, further comprising a plurality of baffles situated in a plurality of spaces between thermoelectric elements of the plurality of thermoelectric elements.

5. The system of claim 1, wherein the second plate comprises a cavity configured to house an electronic component.

6. The system of claim 1, further comprising a fin situated on the second plate.

7. The system of claim 1, further comprising a diaphragm situated in the second plate.

8. The system of claim 1, wherein:
the first surface is a surface of a pipe; and
the environment is a sea water environment having over 20 psi of pressure.

9. A method comprising:
thermally coupling a first plate to a first surface;
thermally coupling a second plate to an environment, the environment comprising a temperature that is different than the first surface; and
generating electricity using a thermoelectric device based on a temperature gradient between the first plate and the second plate, the thermoelectric device comprising:
a plurality of thermoelectric elements submersed in a dielectric fluid, wherein the dielectric fluid comprises non-compressible filler;
a third plate coupled to the plurality of thermoelectric elements and thermally coupled to the first plate; and
a fourth plate coupled to the plurality of thermoelectric elements and thermally coupled to the second plate.

10. The method of claim 9, wherein:
the first plate comprises a first gasket; and
the second plate comprises a second gasket.

11. The method of claim 9, wherein a wall comprising thermally insulative material is situated between the first plate and the second plate, the wall situated around the thermoelectric device.

12. The method of claim 9, wherein a plurality of spaces between thermoelectric elements of the plurality of thermoelectric elements comprise a plurality of baffles.

13. The method of claim 9, further comprising providing electrical power to an electronic component housed in a cavity of the second plate.

14. The method of claim 9, wherein a fin is situated on the second plate.

15. The method of claim 9, wherein a diaphragm is situated in the second plate.

16. The method of claim 9, wherein:
the first surface is a surface of a pipe; and
the environment is a sea water environment having over 20 psi of pressure.

17. A system comprising:
a first plate, the first plate arranged to be thermally coupled to a pipe;
a second plate, the second plate arranged to be thermally coupled to a sea water environment having over 20 psi of pressure, the temperature of the sea water environment being over 10 degrees Fahrenheit different than the first surface;
a thermoelectric device, comprising:
a plurality of thermoelectric elements;
a third plate coupled to the plurality of thermoelectric elements and thermally coupled to the first plate;
a fourth plate coupled to the plurality of thermoelectric elements and thermally coupled to the second plate;
dielectric fluid arranged between the first plate and the second plate, the thermoelectric elements submersed in the dielectric fluid, the dielectric fluid comprising non-compressible powder; and
a wall situated between the first plate and the second plate, the wall situated around the thermoelectric device, the wall comprising thermally insulative material.

18. The system of claim 17, further comprising insulation coupled to the first plate and the second plate.

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